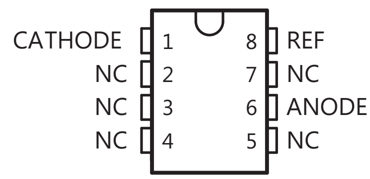
CLASS V, PRECISION PROGRAMMABLE REFERENCE

Check for Samples: TL1431-SP

FEATURES

- **QMLV Qualified to 100k Rad RHA, SMD 5962R99620**
- **0.4% Initial Voltage Tolerance**
- **0.2-Ω Typical Output Impedance**
- **Fast Turnon…500 ns**
- **Sink Current Capability…1 mA to 100 mA**
- **Low Reference Current (REF)**
- **Adjustable Output Voltage…$V_{I(ref)}$ to 36 V**

JG PACKAGE
(TOP VIEW)



NC – No internal connection

DESCRIPTION/ORDERING INFORMATION

The TL1431 is a precision programmable reference with specified thermal stability over automotive, commercial, and military temperature ranges. The output voltage can be set to any value between $V_{I(ref)}$ (approximately 2.5 V) and 36 V with two external resistors. This device has a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turnon characteristic, making the device an excellent replacement for Zener diodes and other types of references in applications such as onboard regulation, adjustable power supplies, and switching power supplies.

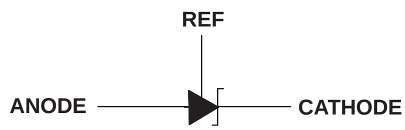
The TL1431 is characterized for operation over the full military temperature range of –55°C to 125°C.

ORDERING INFORMATION(1)

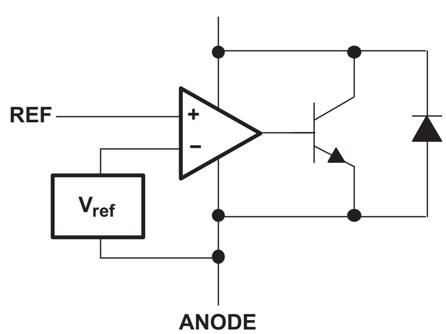
T_A	PACKAGE		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–55°C to 125°C	CDIP – JG	Tube of 50	5962-9962001VPA	9962001VPA
			5962R9962001VPA	R9962001VPA
	CFP – U		5962R9962001VHA (Preview)	R9962001VHA

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

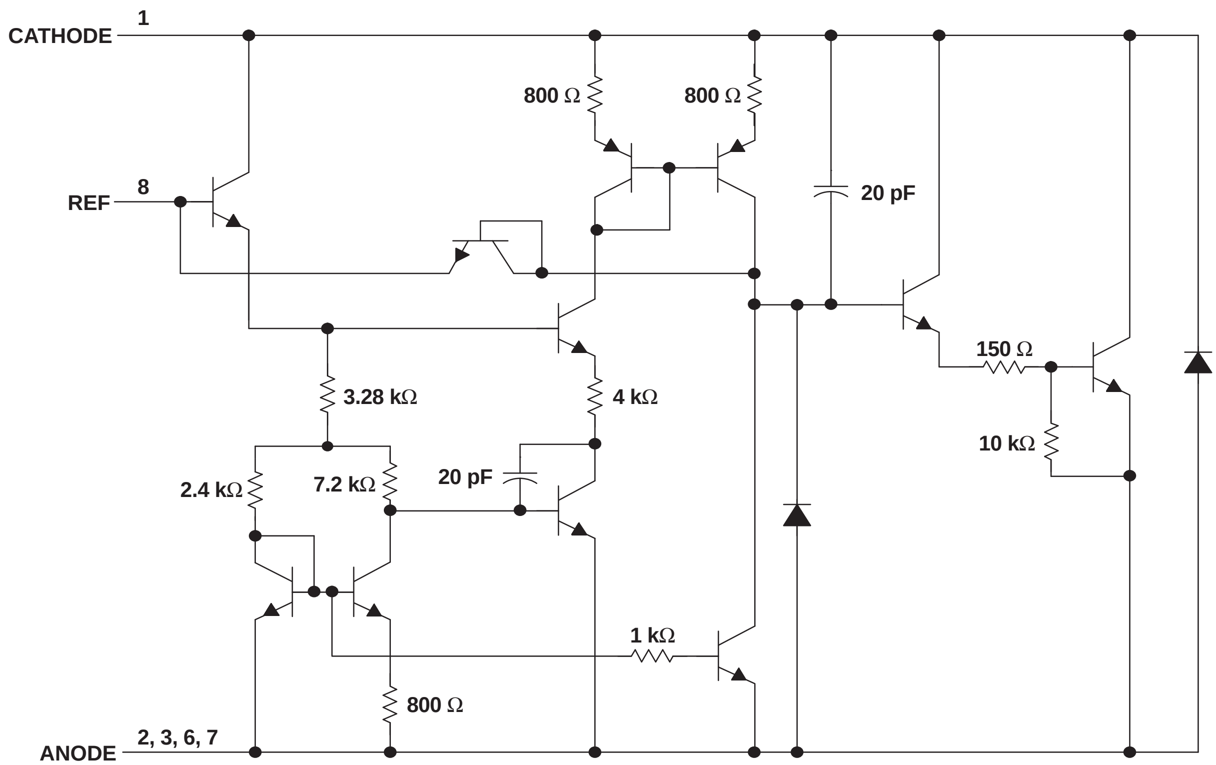
SYMBOL



FUNCTIONAL BLOCK DIAGRAM



EQUIVALENT SCHEMATIC



Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{KA}	Cathode voltage(2)			37	V
I_{KA}	Continuous cathode current range		–100	150	mA
$I_{I(ref)}$	Reference input current range		–0.05	10	mA
θ_{JC}	Package thermal impedance(3) (4)	JG package		14.5	°C/W
		U package		1.91	
T_J	Operating virtual junction temperature			150	°C
	Lead temperature	1,6 mm (1/16 in) from case for 10 s		260	°C
T_{stg}	Storage temperature range		–65	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to ANODE, unless otherwise noted.
(3) Maximum power dissipation is a function of $T_{J(max)}$, θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_{J(max)} – T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(4) The package thermal impedance is calculated in accordance with MIL-STD-883.

Recommended Operating Conditions

		MIN	MAX	UNIT
V_{KA}	Cathode voltage	$V_{I(ref)}$	36	V
I_{KA}	Cathode current	1	100	mA
T_A	Operating free-air temperature	–55	125	°C

Electrical Characteristics

at specified free-air temperature, I_{KA} = 10 mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A (1)	TEST CIRCUIT	MIN	TYP	MAX	UNIT
$V_{I(ref)}$	Reference input voltage	$V_{KA} = V_{I(ref)}$	25°C	Figure 1	2475	2500	2540	mV
			Full range		2460		2550	
$V_{I(dev)}$	Deviation of reference input voltage over full temperature range (2)	$V_{KA} = V_{I(ref)}$	Full range	Figure 1		17	55 (3)	mV
$\frac{\Delta V_{I(ref)}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	ΔV_{KA} = 3 V to 36 V	Full range	Figure 2		–1.1	–2	mV/V
$I_{I(ref)}$	Reference input current	R1 = 10 kΩ, R2 = ∞	25°C	Figure 2		1.5	2.5	μA
			Full range				5	
$I_{I(dev)}$	Deviation of reference input current over full temperature range (2)	R1 = 10 kΩ, R2 = ∞	Full range	Figure 2		0.5	3 (3)	μA
I_{min}	Minimum cathode current for regulation	$V_{KA} = V_{I(ref)}$	25°C	Figure 1		0.45	1	mA
I_{off}	Off-state cathode current	V_{KA} = 36 V, $V_{I(ref)}$ = 0	25°C	Figure 3		0.18	0.5	μA
			Full range				2	
$\lvert z_{KA}\rvert$	Output impedance (4)	$V_{KA} = V_{I(ref)}$, f ≤ 1 kHz, I_{KA} = 1 mA to 100 mA	25°C	Figure 1		0.2	0.4	Ω

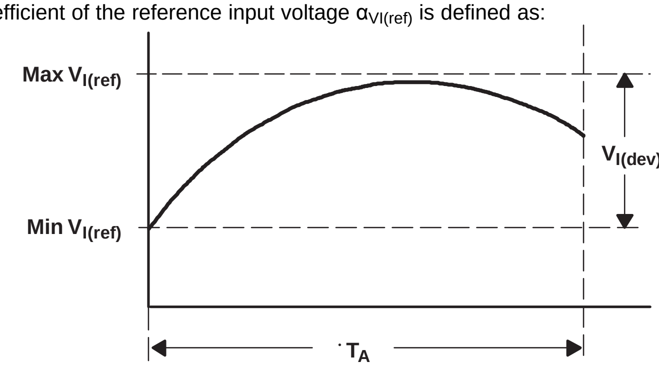
(1) Full range is –55°C to 125°C.

(2) The deviation parameters $V_{I(dev)}$ and $I_{I(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage $\alpha_{VI(ref)}$ is defined as:

$$\left|\alpha_{VI(ref)}\right| \left(\frac{ppm}{^{\circ}C}\right) = \frac{\left(\frac{V_{I(dev)}}{V_{I(ref)} \text{ at } 25^{\circ}C}\right) \times 10^{6}}{\Delta T_A}$$

where:

ΔT_A is the rated operating temperature range of the device.



$\alpha_{VI(ref)}$ is positive or negative, depending on whether minimum $V_{I(ref)}$ or maximum $V_{I(ref)}$, respectively, occurs at the lower temperature.

(3) On products compliant to MIL-PRF-38535, this parameter is not production tested.

(4) The output impedance is defined as: $\lvert z_{KA}\rvert = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by: $\lvert z'\rvert = \frac{\Delta V}{\Delta I}$, which is approximately equal to $\lvert z_{KA}\rvert \left(1 + \frac{R1}{R2}\right)$.

PARAMETER MEASUREMENT INFORMATION

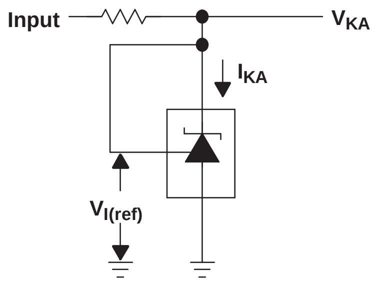


Figure 1. Test Circuit for $V_{(KA)} = V_{ref}$

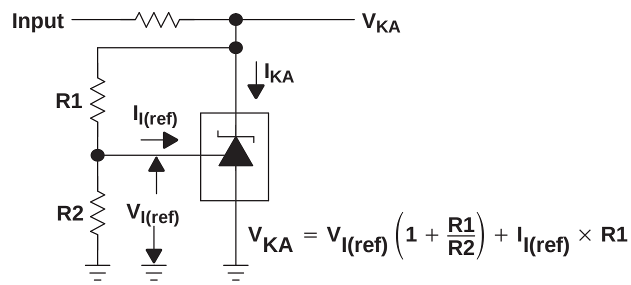


Figure 2. Test Circuit for $V_{(KA)} > V_{ref}$

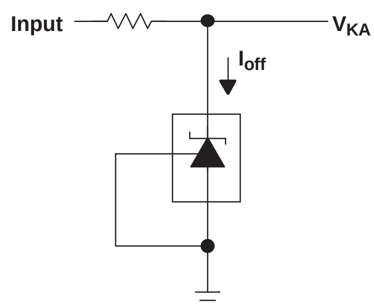


Figure 3. Test Circuit for I_{off}

TYPICAL CHARACTERISTICS

Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE

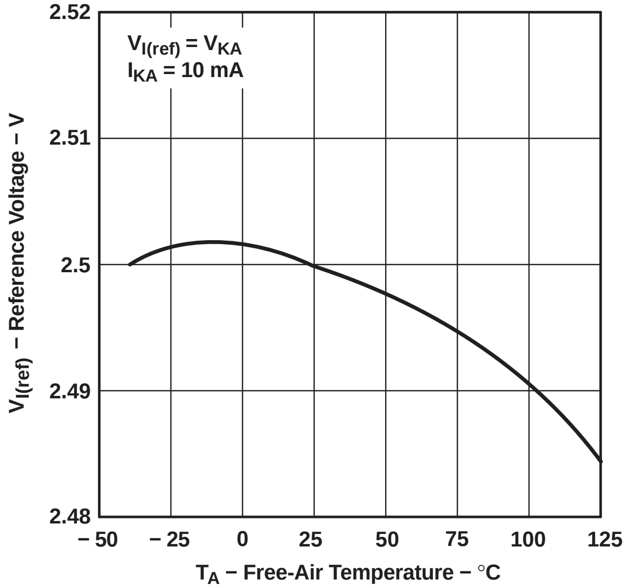


Figure 4.

REFERENCE CURRENT vs FREE-AIR TEMPERATURE

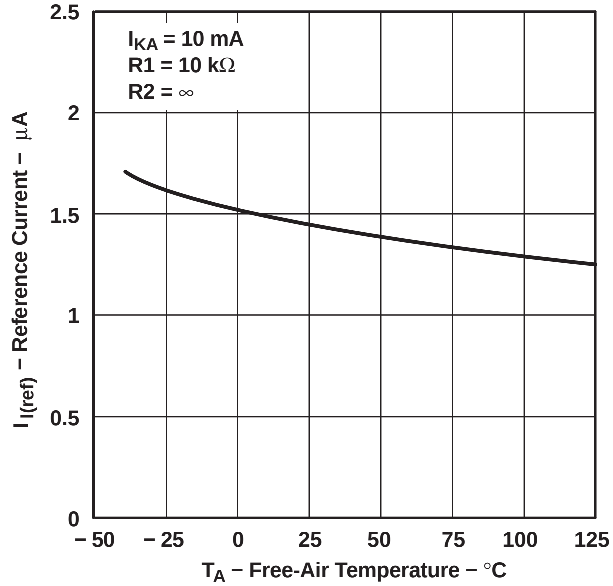


Figure 5.

CATHODE CURRENT vs CATHODE VOLTAGE

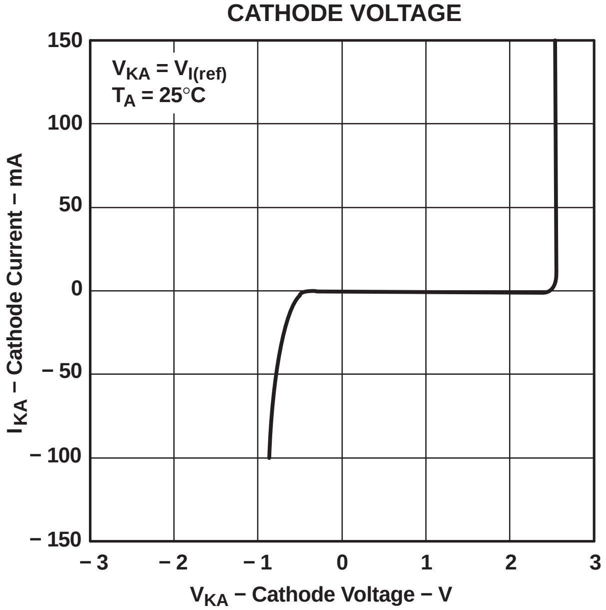


Figure 6.

CATHODE CURRENT vs CATHODE VOLTAGE

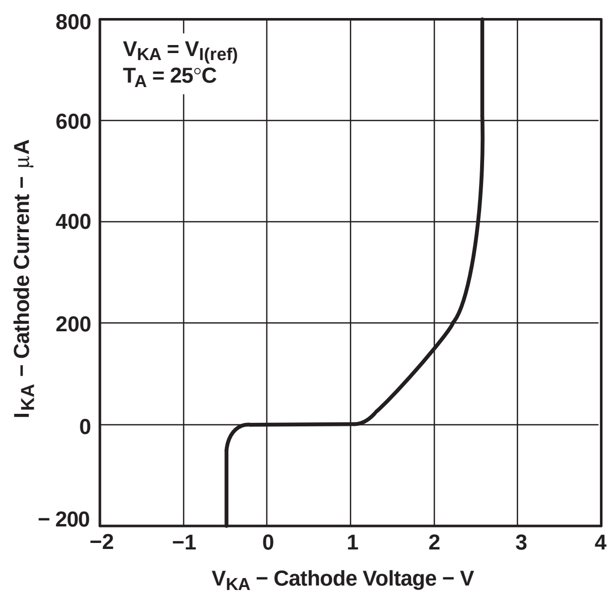


Figure 7.

TYPICAL CHARACTERISTICS (continued)

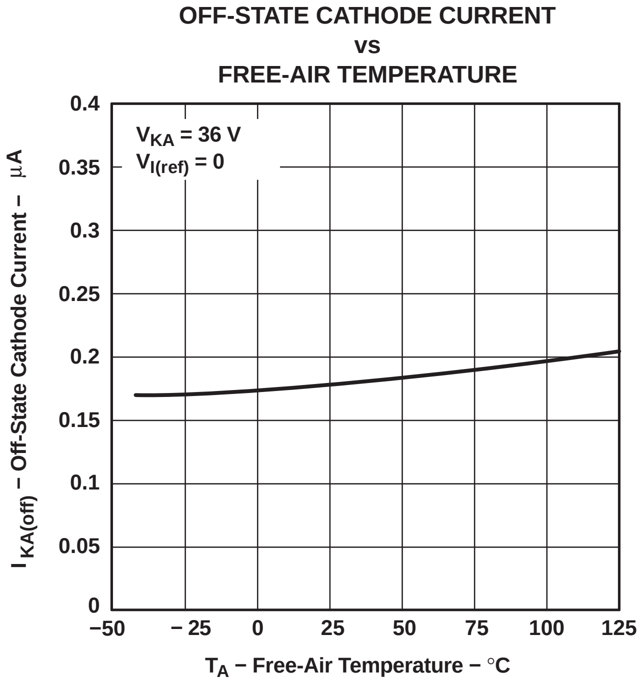


Figure 8.

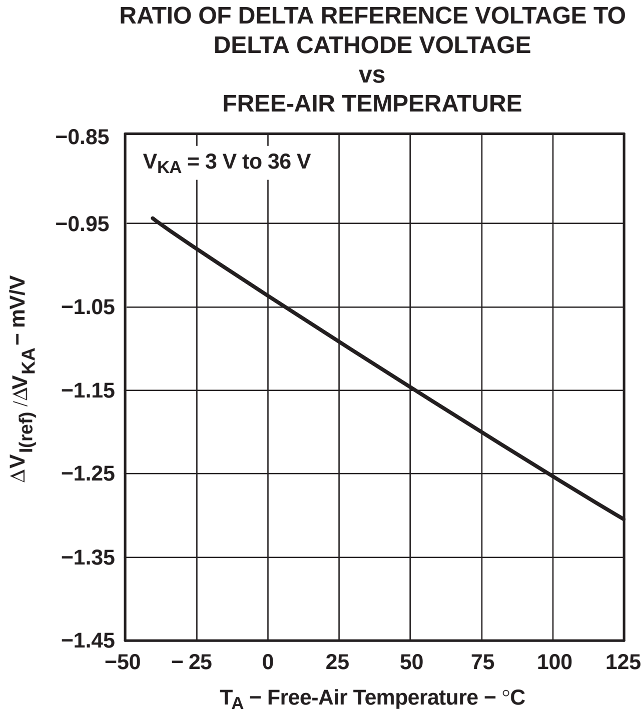


Figure 9.

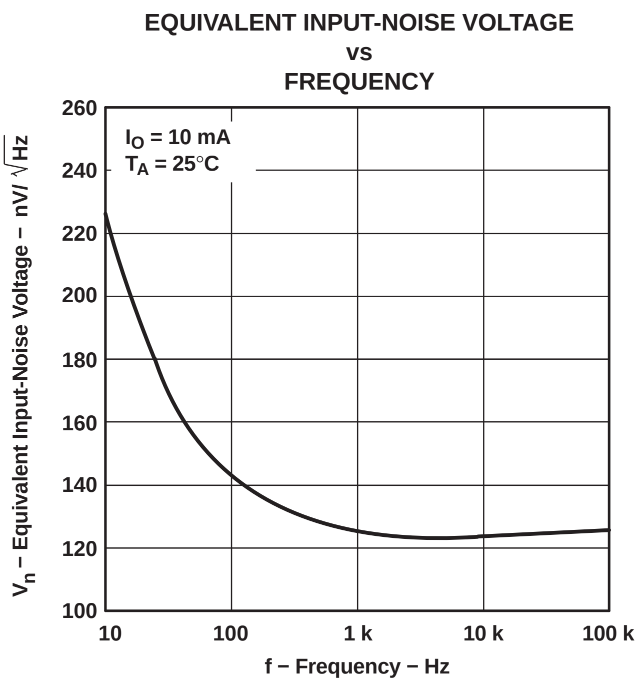


Figure 10.

APPLICATION INFORMATION

A. R should provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

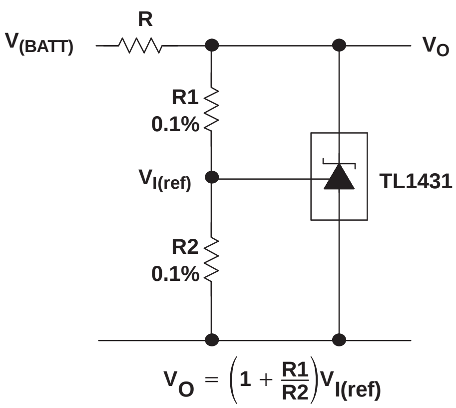


Figure 16. Shunt Regulator

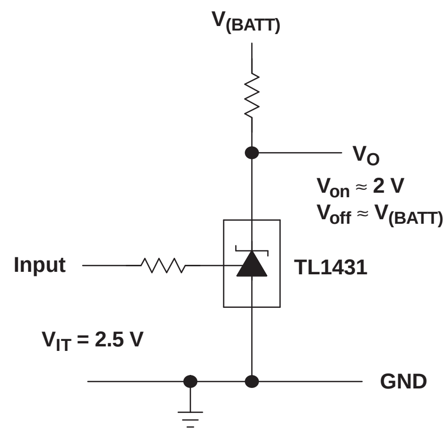


Figure 17. Single-Supply Comparator With Temperature-Compensated Threshold

A. R should provide cathode current ≥1 mA to the TL1431 at minimum $V_{(BATT)}$.

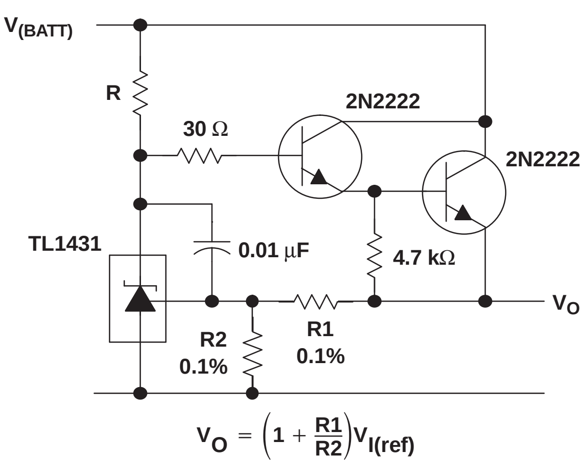


Figure 18. Precision High-Current Series Regulator

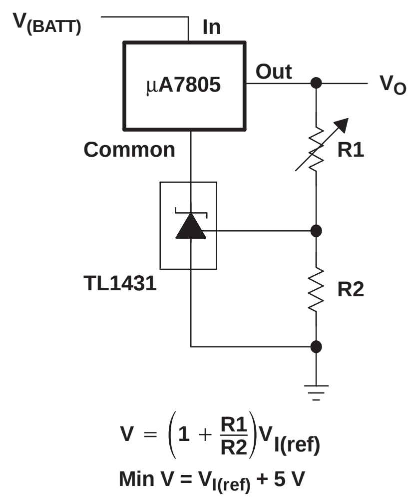
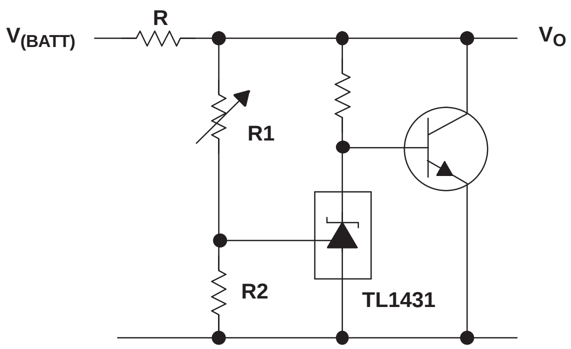


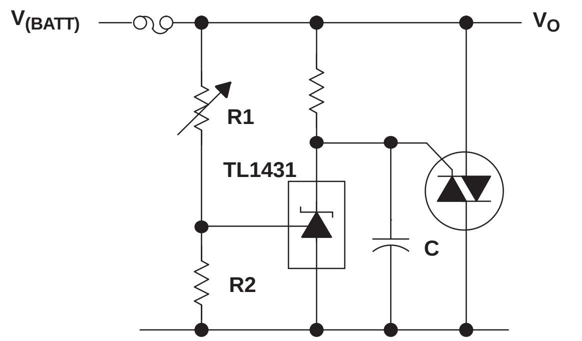
Figure 19. Output Control of a Three-Terminal Fixed Regulator

A. Refer to the stability boundary conditions in Figure 15 to determine allowable values for C.



$$V_O = \left(1 + \frac{R1}{R2}\right) V_{I(ref)}$$

Figure 20. Higher-Current Shunt Regulator



$$V_{trip} = \left(1 + \frac{R1}{R2}\right) V_{I(ref)}$$

Figure 21. Crowbar

A. R_b should provide cathode current ≥1 mA to the TL1431.

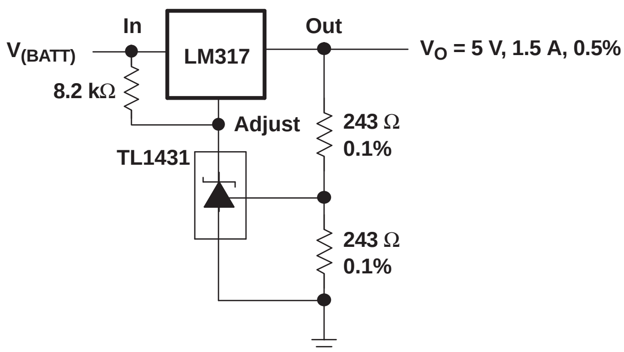


Figure 22. Precision 5-V, 1.5-A, 0.5% Regulator

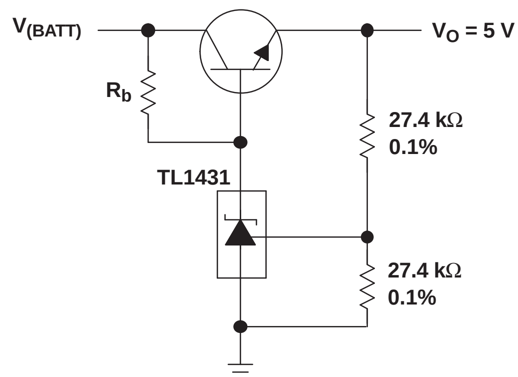


Figure 23. 5-V Precision Regulator

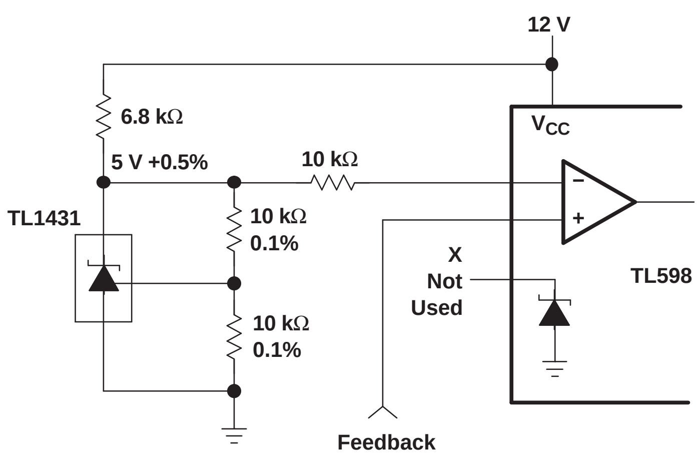
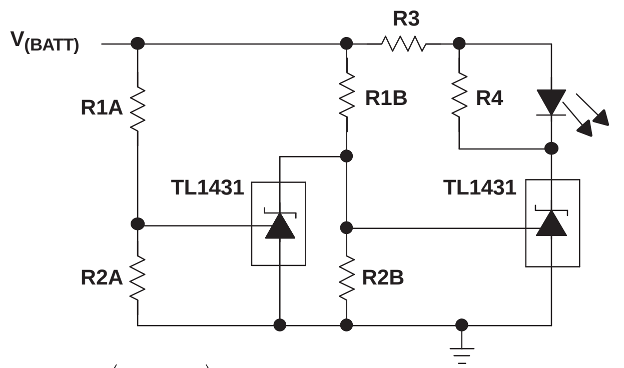


Figure 24. PWM Converter With 0.5% Reference

A. Select R3 and R4 to provide the desired LED intensity and cathode current ≥1 mA to the TL1431.

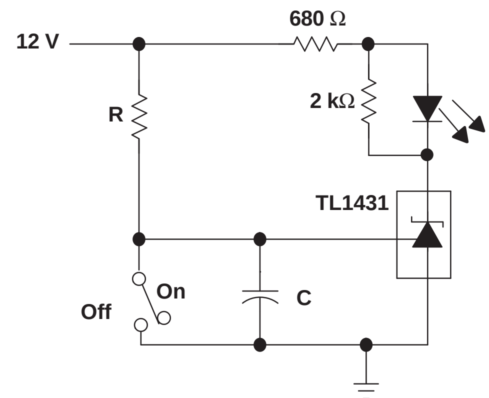


$$\text{Low Limit} = \left(1 + \frac{R1B}{R2B}\right) V_{I(ref)}$$

$$\text{High Limit} = \left(1 + \frac{R1A}{R2A}\right) V_{I(ref)}$$

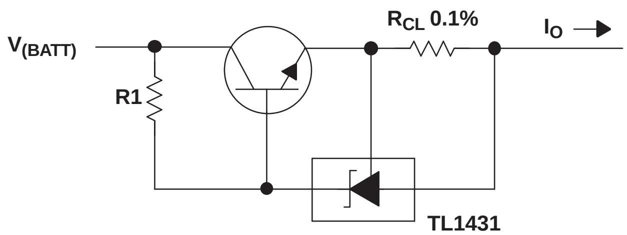
LED on When
Low Limit < $V_{(BATT)}$ < High Limit

Figure 25. Voltage Monitor



$$\text{Delay} = R \times C \times I_I \frac{12\ V}{(12\ V) - V_{I(ref)}}$$

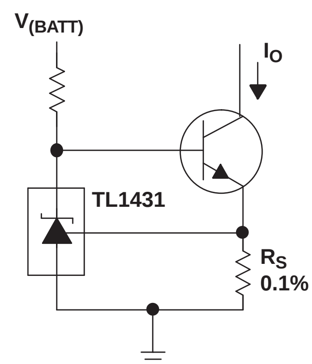
Figure 26. Delay Timer



$$I_O = \frac{V_{I(ref)}}{R_{CL}} + I_{KA}$$

$$R1 = \frac{V_{(BATT)}}{\left(\frac{I_O}{h_{FE}}\right) + I_{KA}}$$

Figure 27. Precision Current Limiter



$$I_O = \frac{V_{I(ref)}}{R_S}$$

Figure 28. Precision Constant-Current Sink

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
5962-9962001VPA	ACTIVE	CDIP	JG	8	1	TBD	A42	N / A for Pkg Type	-55 to 125	9962001VPA TL1431M	Samples
5962R9962001VPA	PREVIEW	CDIP	JG	8	1	TBD	Call TI	Call TI	-55 to 125	R9962001VPA TL1431M	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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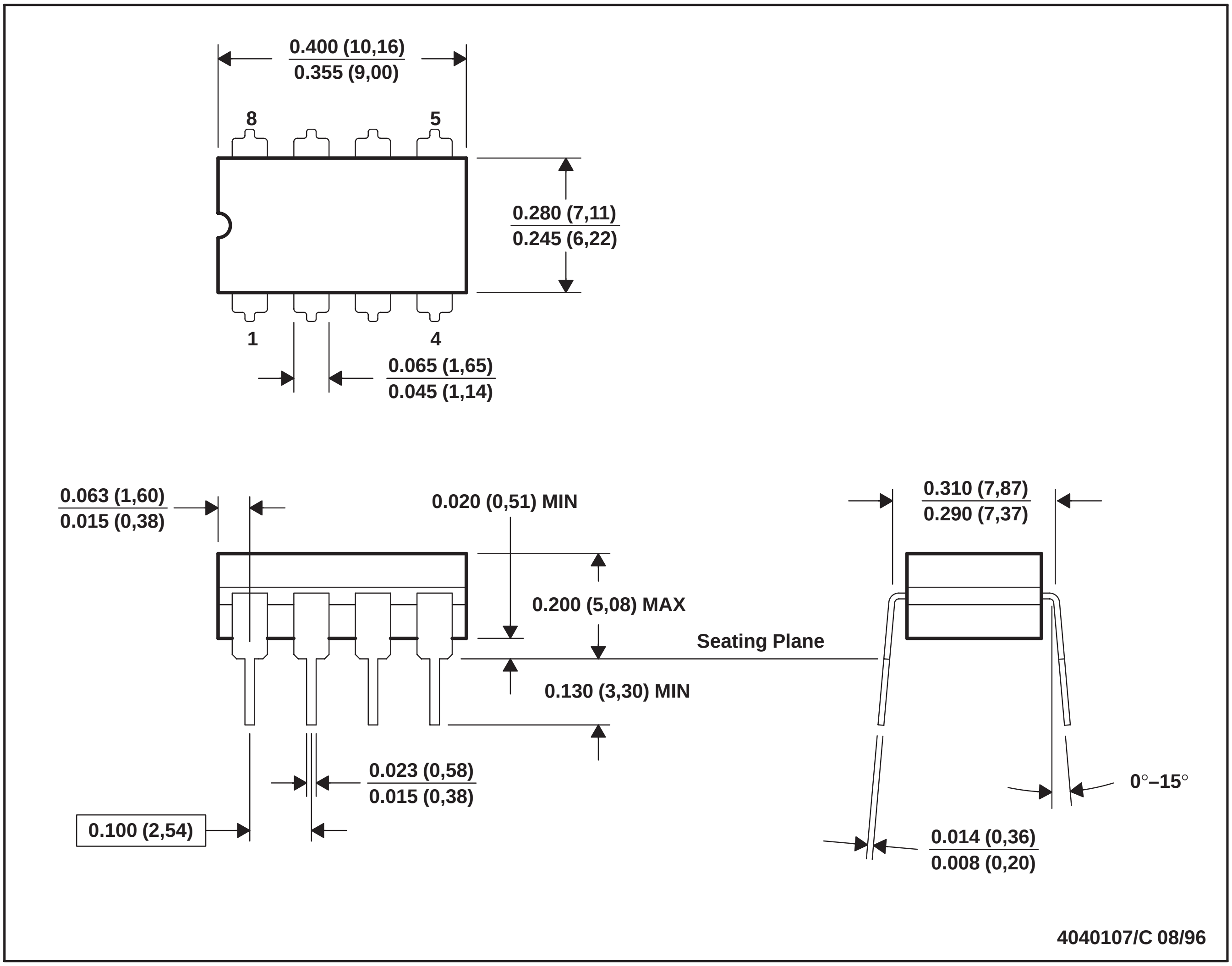
OTHER QUALIFIED VERSIONS OF TL1431-SP :

- Catalog: TL1431
- Automotive: TL1431-Q1
- Enhanced Product: TL1431-EP
- Military: TL1431M

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

JG (R-GDIP-T8) **CERAMIC DUAL-IN-LINE**



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification.
- E. Falls within MIL STD 1835 GDIP1-T8

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